5. On the Development of the Lung-Books in Scorpio fulvipes.

By Malcolm Laurie, B.Sc., F.L.S.

eingeg. 29. December 1891.

The following observations on the development of the lung-books of *Scorpio fulvipes*, and the light thrown by them on the probable mode of origin of these structures from the gills of an aquatic ancestor, were made by me while investigating the embryology of this form, an account of which was published in the Quarterly Journal of Microscopical Science, Vol. XXXII, p. 587. In the earlier stages the lung-books present no special points of interest being simple ingrowths of the ventral surface of the abdominal segments precisely similar to what I have described in *Euscorpius italicus*[1]. In the latest stage which I have examined, however, the lamellae are well developed and have the same structure as in the adult though they are not so numerous. They differ from those of the adult however, very strikingly in position. In the adult the lamellae stand perpendicular to the ventral surface of the body and directly over the stigmatic opening (fig. 1).

Fig. 1.

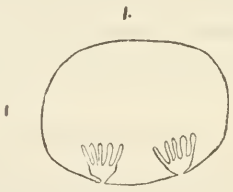

Fig. 2.

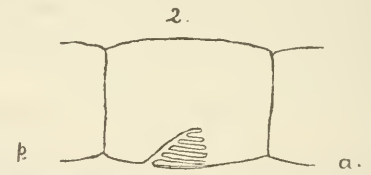

Fig. 1. Diagrammatic transverse section of adult *Scorpio* to shew the position of the lamellae of the lung-books.

Fig. 2. Diagrammatic longitudinal section of Embryo *Scorpio*. *a* anterior; *p* posterior end.

The lamellae are further placed parallel to the axis of the body, i. e. with their flat surfaces directed towards the sides of the body and their edges towards the anterior and posterior ends. In the embryo, on the other hand, the lamellae lie horizontally and parallel to the ventral surface (fig. 2) resembling in this respect the lamellae of the Araneidae. The stigmatic opening is situated at the postero-internal angle of the lamellae. The change in position of the lamellae in passing from the embryonic to the adult condition thus involves a movement of 90° from the horizontal to the vertical position and a further twist of about 45° to bring the lamellae parallel to the axis of the body.

[1] Q. J. M. S. Vol. XXXI.

By what steps this change takes place the material at my disposal does not show.

It seems to me that this embryonic position of the lamellae is calculated to throw some light on the probable mode of derivation of the lung-books of terrestrial Arachnids from the gills of an aquatic ancestral form. At present two theories have been put forward on this point, those namely of Lankester and Macleod.

According to Professor Lankester's theory[2] the lung-books have been formed by the invagination of an abdominal appendage intermediate in form between the gills of *Limulus* and the pectens of *Scorpio*. That such an invagination may take place, and take place as Professor Lankester suggested as an adaptation to the conditions of embryonic life, has been shown by Reichenbach who describes the last pair of abdominal appendages in *Astacus* as forming in this way in the embryo and being evaginated later. There is also nothing in the structure of the adult lung-book to preclude such a mode of derivation. If, however, the embryonic position of the lamellae represents, as I believe it to do, a stage in the phylogenetic history of the race, the probability of Professor Lankester's theory is, I think, considerably diminished, and for the following reason: If we imagine an appendage, bearing a series of lamellae along one side, to be invaginated, so as to form a structure resembling a lung-book, then the stigmatic aperture and air space would bear the same relation to the lamellae which the axis of the appendage bore previous to invagination.

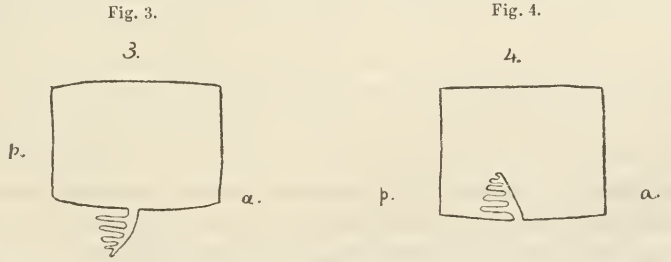

Fig. 3 und 4. Diagrammatic representation of the effects of invagination of an appendage with lamellae attached to the posterior side.

For example, if the lamellae were borne on the posterior margin of the axis of the original appendage then after invagination they would lie on the posterior side of the stigma and air space. A glance at figs. 3 and 4 will, I think, make this point clear. This being so, the appendage, from the invagination of which the arrangement shown in

[2] Q. J. M. S. Vol. XXV. p. 339.

the young of *Scorpio* would result, must have borne a series of gill lamellae on its anterior margin or surface — a type of appendage quite unknown among either recent or fossil aquatic Arachnids, and which would place the gills in a very exposed position.

The theory propounded by Macleod[3] and suggested to him by a study of the lung-books of Spiders, is briefly, as follows: He supposes a pair of platelike abdominal appendages united, like those of *Limulus*, in the middle line and bearing branchial lamellae on their posterior surface, to have become gradually fused round the margin to the ventral surface of the body. The process might perhaps be better described as an extension of the line of attachment along the sides of the appendage so as to convert the space between the appendage and the body wall into a chamber opening to the exterior along a greater or less extent of its posterior border. This theory has much to be said for it. In the first place, it avoids the difficulty as to the original position of the lamellae which we met with in considering Prof. Lankester's theory, as the air space would occupy the position not of the axis but of the free end of the lamellae. Another strong point in its favour is that it is easy to see how the change might arise step by step as the animals took more and more to a terrestrial mode of existence; every step being of advantage as tending to keep the gills longer in a moist condition. The change would thus be a gradual one instead of being sudden as in Professor Lankester's hypothesis.

There is only one point of importance in which I would differ from Macleod. He would derive the lung-books from a pair of appendages fused in the middle line and adduces in favour of this the presence of a transverse groove connecting the lung-books in many forms. The Araneidae are, however, a highly specialized group and the absence of any such structure in the lower Arachnids is to me a strong argument against its having any phylogenetic significance. In the embryo Scorpio the lung-books shew no trace of any structure uniting them, but are separated by a broad, shallow, longitudinal groove which runs down the whole length of the abdomen.

The form, from which I would suggest that the lung-books of the Arachnids have been derived, is one which I have described as existing in *Slimonia* — one of the fossil Eurypterids from the Upper Silurian rocks. In *Slimonia* the abdominal appendages consist of a pair of separate plates on each segment each of which bears on its posterior surface branchial lamellae. These lamellae are attached towards the

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[3] Arch. Biol. Vol. V.

antero-external angle of the plates and their free ends point backwards and inwards, thus corresponding with the position of the lamellae in the embryo of *Scorpio* and in Spiders.

Thus, while accepting Macleod's theory in its main lines, I would suggest that the lung-books of the Arachnids were probably derived from a series of paired platelike appendages, not united in the middle line, by a gradual fusion of their edges with the abdominal walls of the body.

6. Arrangement of keeping alive fresh water animals.

By Dr. J. Dewitz, Berlin.

eingeg. 5. Januar 1892.

Wherever expensive arrangements of biological insitutions are not at our disposal it is rather troublesome to keep fresh water animals alive, as the water intended for certain kinds of animals is to be daily renewed. Hence it would be advantageous to find out a method of preserving fresh water animals without water.

I observed for biological purposes *Paludina vivipara*, a pond snail, common in the North Eastern part of Germany. It is easy to obtain this kind of snail in great quantities in summer and spring in Berlin, the Spree and the canals connecting with that river teeming with the animals mentioned, even in the centre of the city. Still in the late fall and winter all water-animals dip through the mud of the ground and the snails in question can be caught only with great difficulty. This fall now I have collected a large quantity (about 350) of *Paludina* and preserved them as follows:

An appropriate piece of canvas or a small dampened towel having been spred over the bottom and sides of a plate, the snails are put into the plate so as to cover the bottom and sides of the vessel. The molluscs thus arranged form a thin layer and are covered with an other wet towel and placed in a cold room. Care has to be taken that the water does not stagnate. For this purpose the towels are to be wrung out. Every fourth day the snails are to be washed, the dead ones to be removed and the towels to be washed and wrung out again.

This arrangement retains the snails in a permanently damp condition and I have preserved the collected animals, about 350 in number, for three months and I believe that I can keep them alive all through the winter. Still I have to add here that three snails on the avarage die weekly and it seems that the young molluscs being more sensitive to this proceeding than the adult snails show a greater mortality than the latter. Not all species of snails, however, can stand equally well the mentioned treatment. *Bithynia tentaculata*, f. i., was